

Genetic Engineering Gone Wild: Who has say in the future(s)?

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Gene Editing and Gene Drive Systems

de Lorenzo (2013)



2003—The First Specific Proposal for Gene Drives



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Site-specific selfish genes as tools for the control and genetic engineering of natural populations

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Site-specific selfish genes exploit host functions to copy themselves into a defined target DNA sequence, and include homing endonuclease genes, group II introns and some LINE-like transposable elements. If such genes can be engineered to target new host sequences, then they can be used to manipulate natural populations, even if the number of individuals released is a small fraction of the entire population. For example, a genetic load sufficient to eradicate a population can be imposed in fewer than 20 generations, if the target is an essential host gene, the knockout is recessive and the selfish gene has an appropriate promoter. There will be selection for resistance, but several strategies are available for reducing the likelihood of it evolving. These genes may also be used to genetically engineer natural populations, by means of population-wide gene knockouts, gene replacements and genetic transformations. By targeting sexlinked loci just prior to meiosis one may skew the population sex ratio, and by changing the promoter one may limit the spread of the gene to neighbouring populations. The proposed constructs are evolutionarily stable in the face of the mutations most likely to arise during their spread, and strategies are also available for reversing the manipulations.

Homing Endonucleases



(b)



(Johnson & Jasin 2001; Lieber 2010)

Burt 2003



Figure 2. Frequency of the HEG (solid curve) and population mean fitness (dashed curve) assuming e = 0.9 and an initial release frequency of 1%. These results, and all



Sci Am 2014

Gene Editing Tools of Late



(Lorenzen 2013)

CRISPR-Cas9 makes more possibilities easier



BIOTECHNOLOGY

Biologists devise invasion plan for mutations

"Gene drive" technique could fight insect-borne disease, but some call for safeguards



Not just Population Suppression anymore Cargo and easier editing now facilitate:

New traits "engineered in wild" Propagated on their own in "chain reaction"

- Resistance to Disease (or carrying it)
- Resistance to Pests
- Resistance to Herbicide
- Many, many other new traits

Bohannon, Sci Am 2015

Getting Fancy or Dealing with Risk?



Changing populations on islands: Variations on immunization strategy



Getting Fancy or Dealing with Risk?

- Drive A needs to be 100% eradicated
- Mutations? Regular gene flow?





Restore Rats Back to Native Habitat in Eurasia: Eradicate Elsewhere



Burt 2003

"Wide ranging discussions are needed on the *criteria* for deciding whether to eradicate or genetically engineer an entire species"

"Clearly the technology described here is not to be used lightly. Given the suffering caused by some species, neither is it obviously one to be ignored"

Future generations & Gene Editing/Drives How will they see these "criteria"?



Gardiner's "Perfect Storm" of Intergenerational Ethics Translated from Climate Change (2011) to Gene Drives

Temporal Dispersion of Cause and Effect

- Secondary ecological or health ramifications may not be felt for decades

Institutional Inadequacy

- Short time horizons of political institutions (e.g. CBA)

Fragmentation of agency

- Current and future generations separated by time, cannot work together for shared goals
- Motivation to work for present generation only
- Current generation may be morally justified to harm future generations in self-defense

Extreme uncertainty about effects

Delayed & irreversible (Slovic 1987)

Moral Corruption

- Distraction, unreasonable doubt, selective attention, Delusion, False witness, hypocrisy...
- Example: Risk funding? Less regulation of GEOs as technology gains power?

Considering future generations in genetic engineering

- In literature, intergenerational equity is most often discussed in context of longer-term damage from environmental risk (climate change, geoengineering, nuclear waste).
 - 7th generation principle
- Let's get practical with gene editing and gene drives?
 - Could we achieve more (ethically and politically) by thinking out 1-2 generations with genetic engineering?
 - Step wise effect, doable, and can involve direct consultation

A Practical Suggestion for Intergenerational Equity: Let's Start with the Next Generation...

- What does the next generation want (or not want) to see in their future with (or without) genetic engineering?
- We do not know, because we do not ask
- So let's ask, and report back to those who have decision making capacities
- Moral issue we can do something about
- National effort like this has not previously reported in literature



Partners (interested)

- Museum of Life & Science
- NC Museum of Natural Sciences
- Kenan Institute of Engineering, Technology, & Society
- Friday Institute (k-12)
- CSPO (ASU)
- NC COIN
- SynBio Project (Woodrow Wilson Center, DC)

Features (in planning)

- Practical & ethical imperative
- Added benefit of information education & social science research
- Fun, interactive café style dialogues
- Coupled with National survey
- Report back to decision makers in DC (kids taking leadership)
- Kids & Teens 11-17 years old

Possible Theoretical and Practical Framings for "NextGen Voices in GE"

Cotton (2013)

- "Deweyan Backcasting"
 - Imaginative & Empathetic
 - Deliberative process
 - Not focused on prediction
 - Envision desired and undesired futures
 & How to get there
 - Situation and contextual view (discourse ethics)
 - Ethical reflection from agent's point of view of not "god view"
 - Role play (empathy) & "dramatic rehearsal"

Adam & Groves (2011)

- Ethics of Care
 - Based on feminist and phenomenological concepts of care
 - Current legal and political systems privilege current generations (based on reciprocal responsibility & autonomy)
 - Non-reciprocal, care-based relationships
 - Extend relationship to posterity
 - Interdependency, humility, restraint (consistent with precaution)
 - "Imagine different way of acting responsibly in creating futures & reshaping legal and political expressions"

Acknowledgments

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